



# exploration

...the essence of the human spirit.

*Frank Borman*  
APOLLO ASTRONAUT





# Our Inspiration and Our Champions



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# The Vision for Space Exploration

## Presidential Direction to NASA, January 2004



### A RENEWED SPIRIT OF DISCOVERY

*The President's Vision for  
U.S. Space Exploration*



PRESIDENT GEORGE W. BUSH  
JANUARY 2004

- Implement a sustained and affordable human and robotic program to explore the solar system and beyond
- Extend human presence across the solar system, starting with a human return to the Moon by the year 2020, in preparation for human exploration of Mars and other destinations;
- Develop the innovative technologies, knowledge, and infrastructures both to explore and to support decisions about the destinations for human exploration; and
- Promote international and commercial participation in exploration to further U.S. scientific, security, and economic interests.



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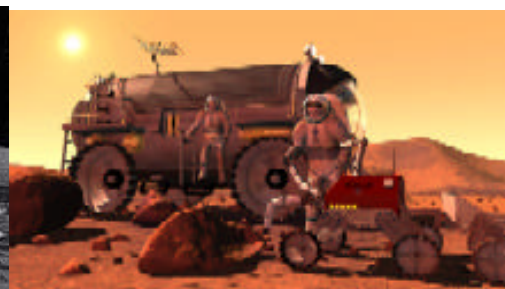


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# The Vision's Evolutionary Strategy

## Demonstrate Capability, Extend Exploration

- **Technology advancement** reduces mission costs and supports expanded human exploration
- **Systems testing** and technology test beds to develop reliability in harsh environments
- **Expand mission and science surface operations** experience and techniques
- **Human and machine collaboration:** Machines serve as an extension of human explorers, together achieving more than either can do alone
- **Breaking the bonds of dependence on Earth:** (e.g./Life Science/Closed loop life support tests)
- **Power generation and propulsion** development and testing
- **Common investments** in hardware systems for Moon, Mars and other space objectives

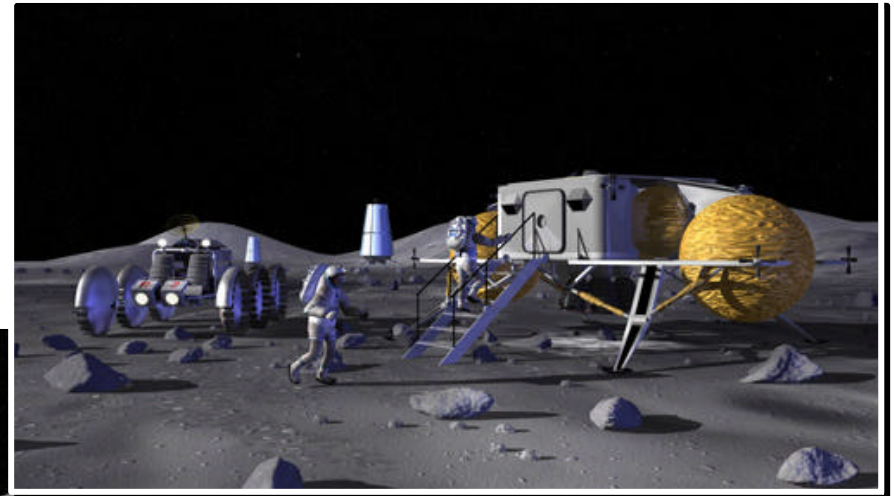
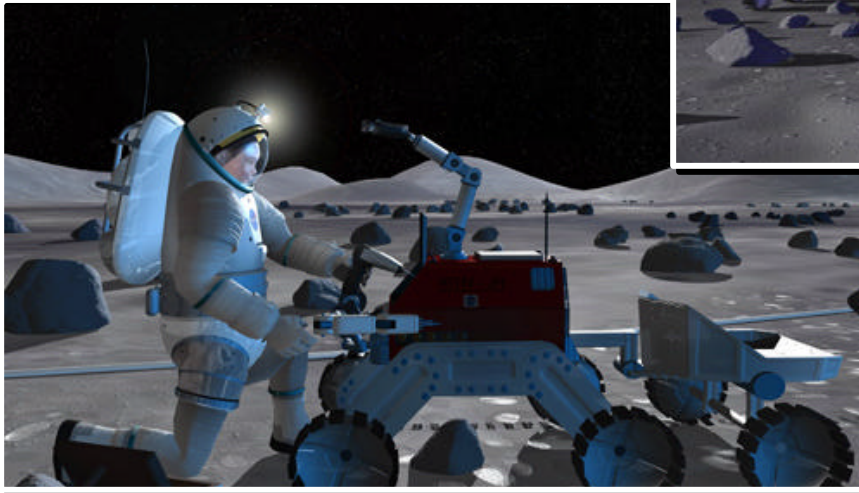




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# Exploring the Moon

## Operational Demonstrations Prepare for Mars







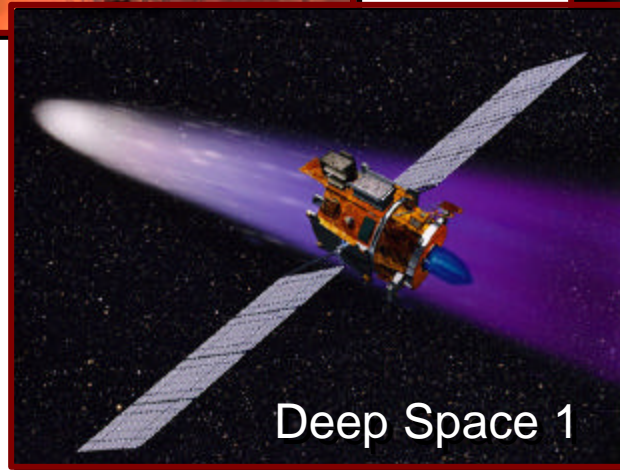
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# Exploring Mars and Beyond

## Expand Operations Experience & Techniques



Martian landscape 3/15/04



Deep Space 1



Jupiter and Io



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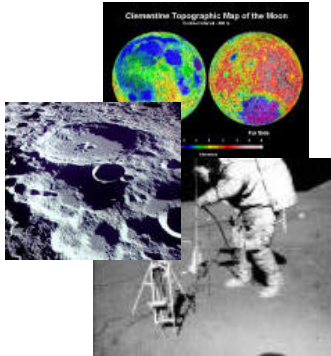
# The Vision's Science

## All Destinations Play a Role

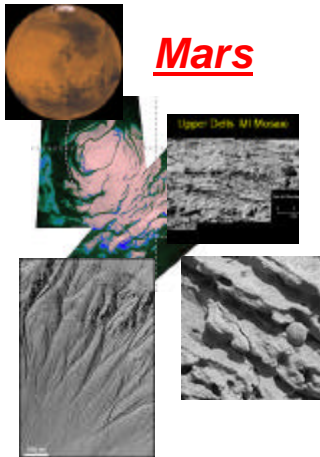
### Search for Life as a Focus

- What do our studies of planetary systems and biogeochemistry tell us about the past and present habitability of planets?
- What signatures would suggest evidence of organic activity or habitability in planetary systems?
- Have planets or moons in our Solar System supported life in the past or the present?
- How abundant are planets around other stars and do they show evidence of habitability or life?

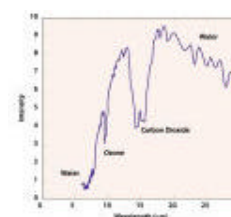
### Earth's Moon



### Mars

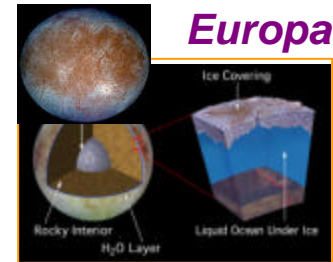


### Astrobiology



### Outer Planets

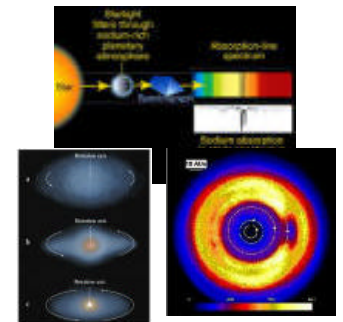
#### Europa



#### Titan



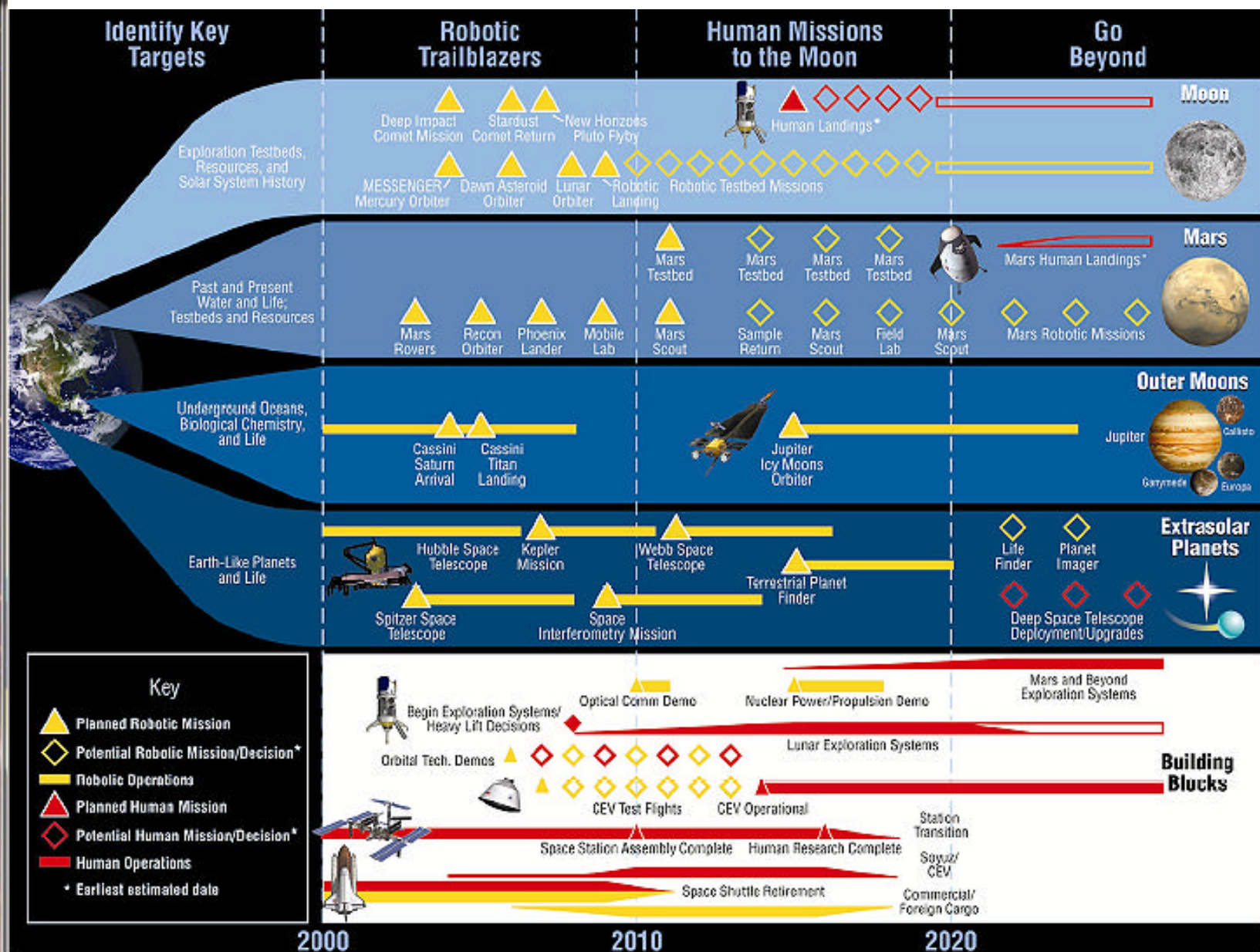
### Extra-Solar Planets







# The Vision's Scope Across Multiple Worlds







# Exploration Milestones

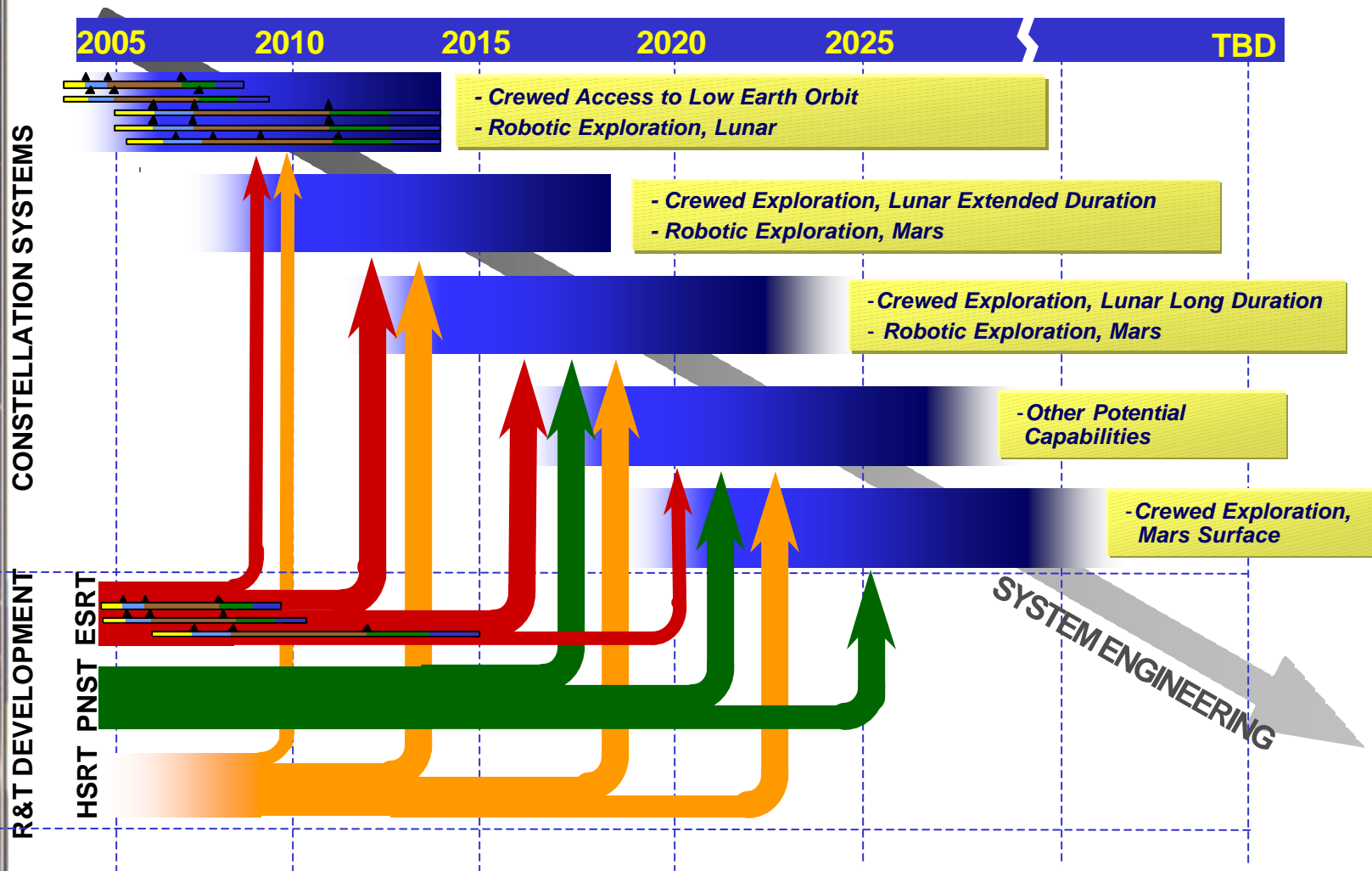
## ***Incremental milestones demonstrate success:***

- ***2008: Initial flight test of CEV***
- ***2008: Launch first lunar robotic orbiter***
- ***2009-2010: Robotic mission to lunar surface***
- ***2011 First Uncrewed CEV flight***
- ***2014: First crewed CEV flight***
- ***2012-2015: Prometheus-1 Nuclear Demonstration***
- ***2015-2020: First human mission to the moon***



# Spiral Development Acquisition Strategy

## Permits Optimal System-of-Systems Development



ESRT: Exploration Systems Research & Technology  
PNST: Prometheus Nuclear Systems Technology  
HSRT: Human System Research & Technology



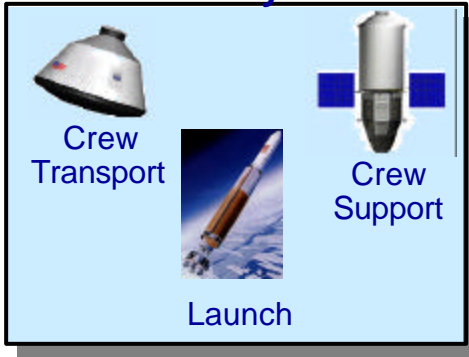


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# System-of-Systems Integration

## Multiple Elements & Interfaces

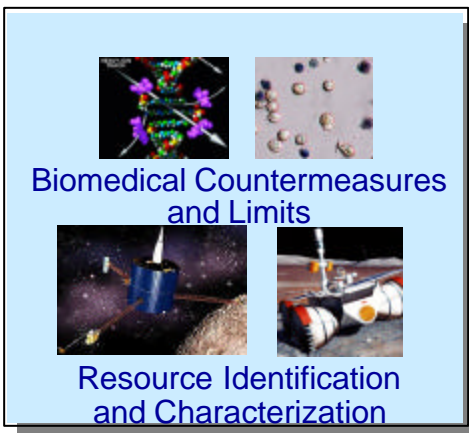
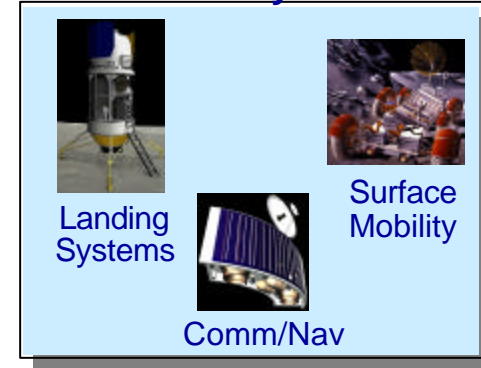
### Transit and Launch Systems



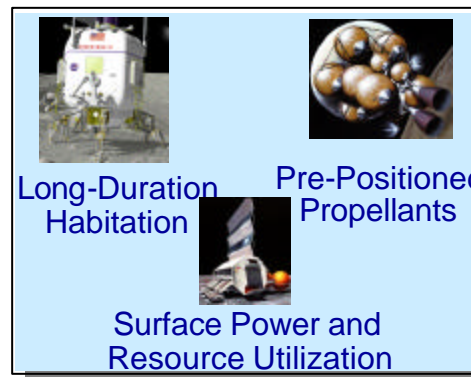
### The Human: an Essential Element of the System of Systems



### Surface and Orbital Systems



### Supporting Research



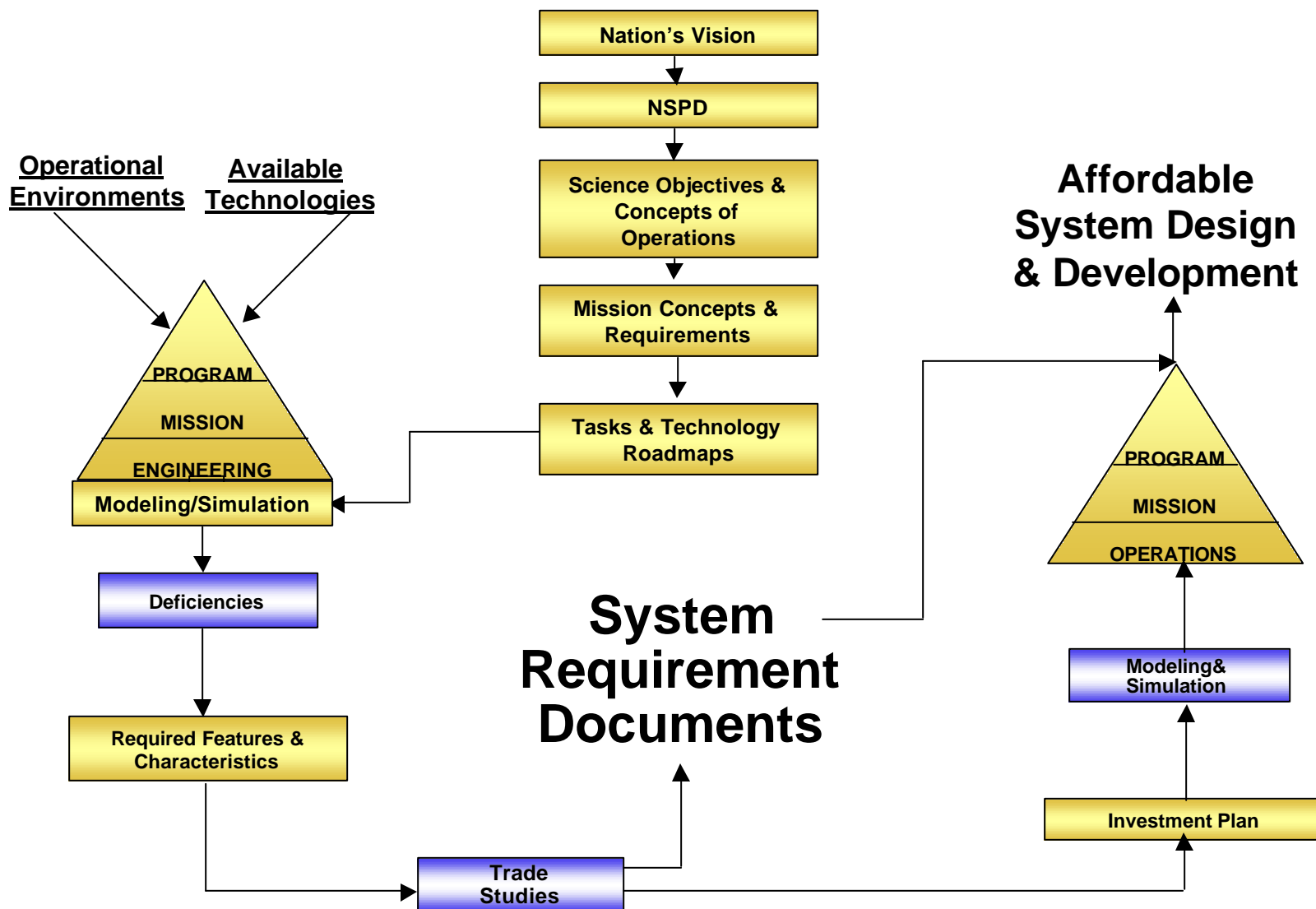
### Technology Options



### Commonality/Evolvability For Future Missions

# Strategy-to-Task-to-Technology Process

## Defining Requirements, Planning Investments



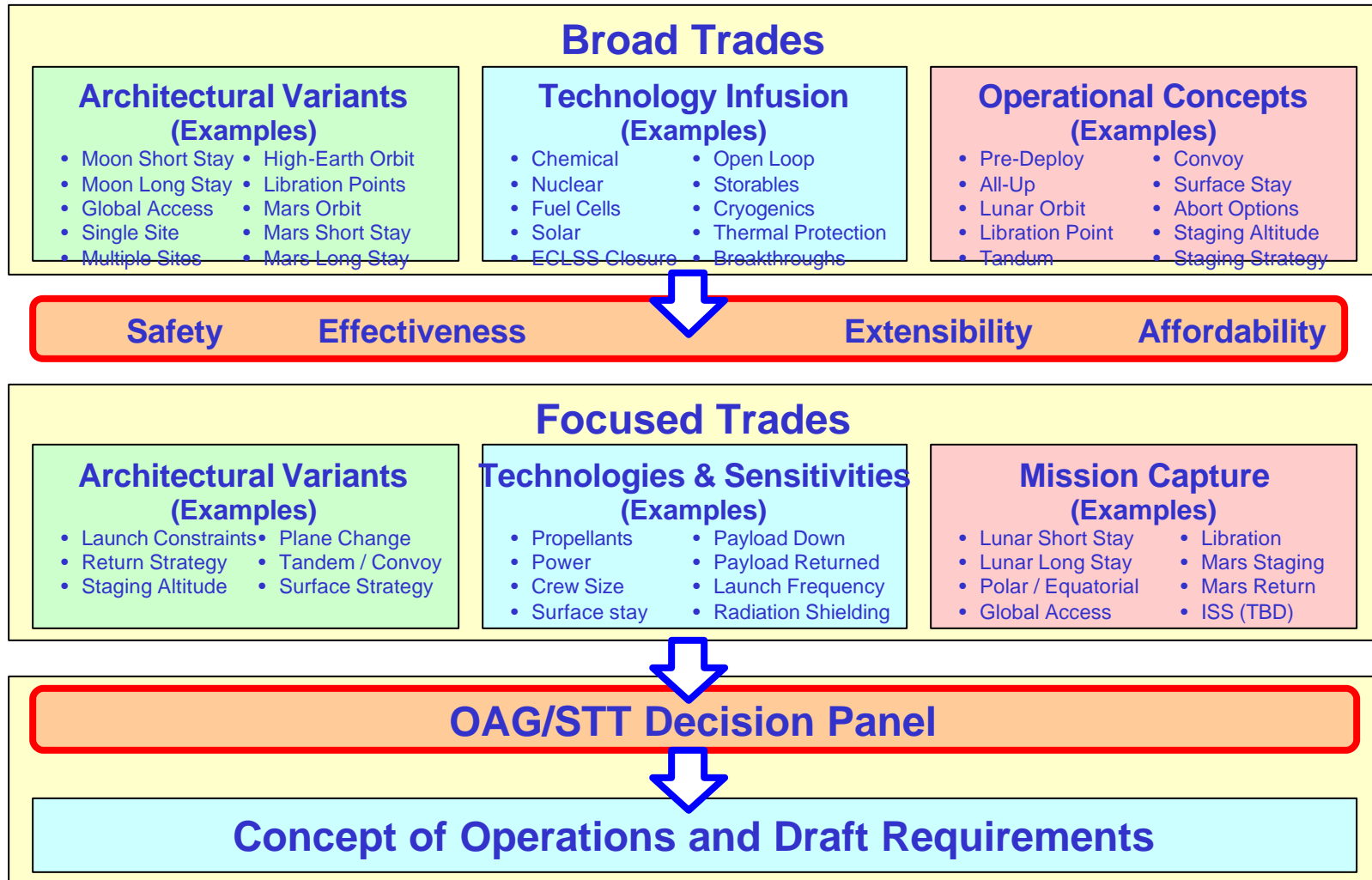




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# Rigor in Requirements Definition

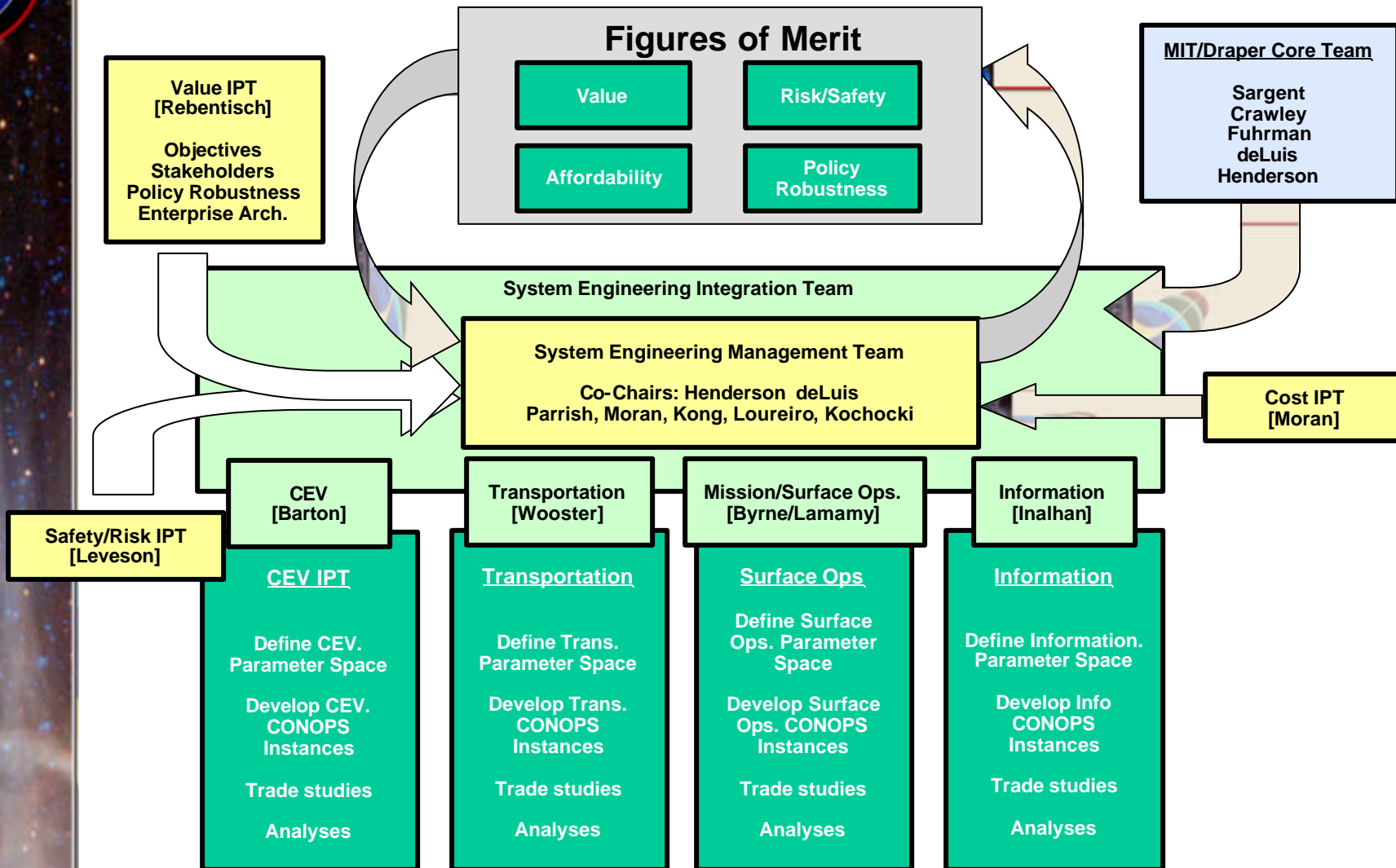
## Methodical Approach to System-of-Systems





# MIT Contributions to S-T-T

## Concept Exploration & Refinement



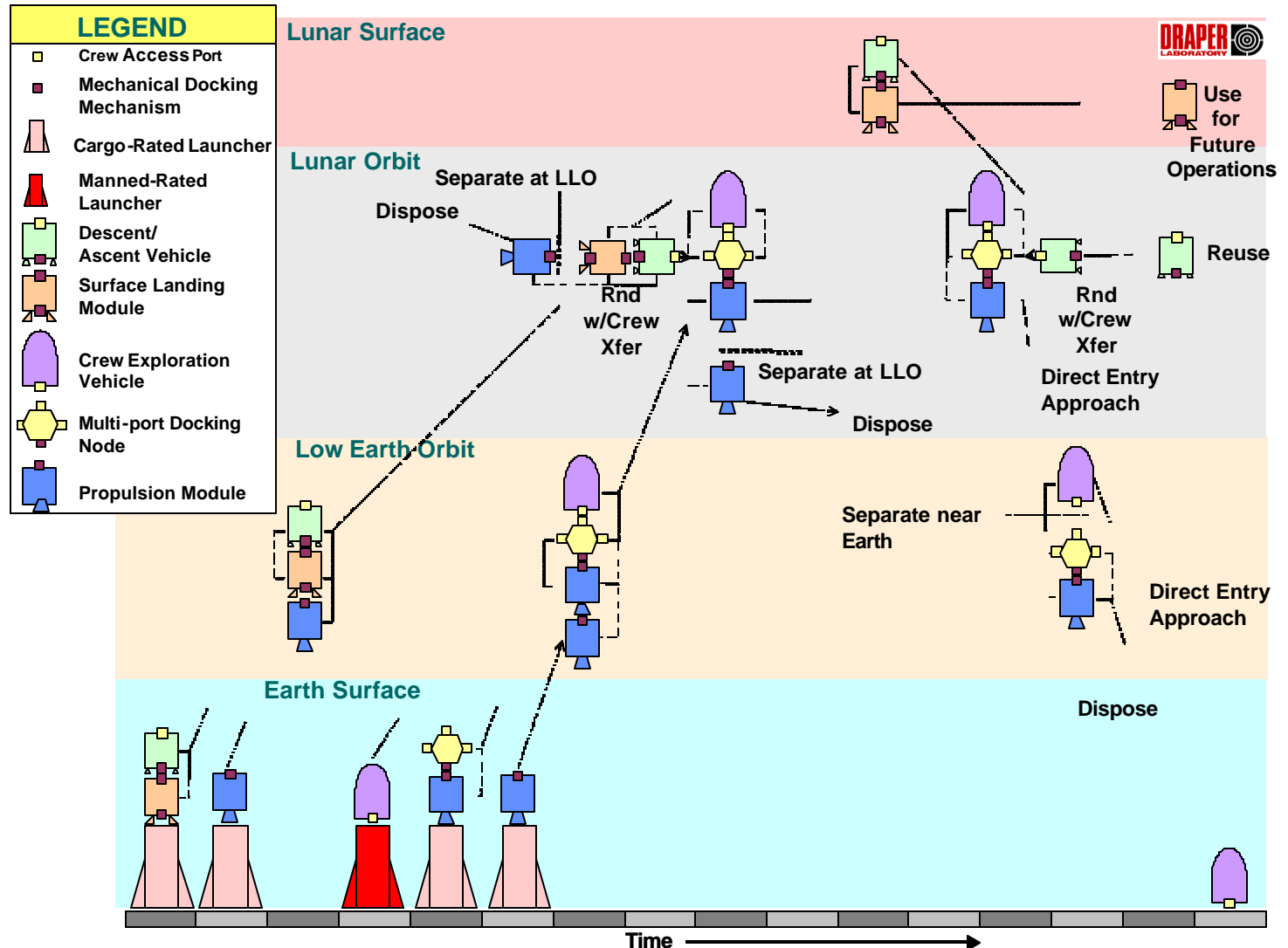




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# MIT Contributions to S-T-T

## Baseline CE&R Architecture

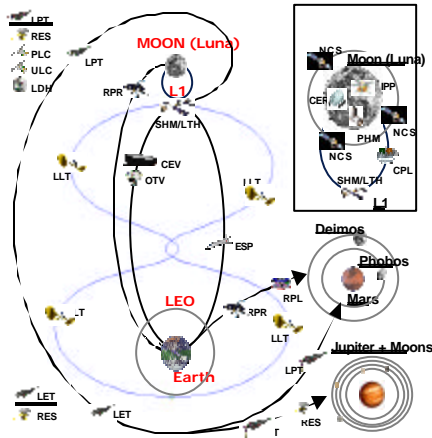




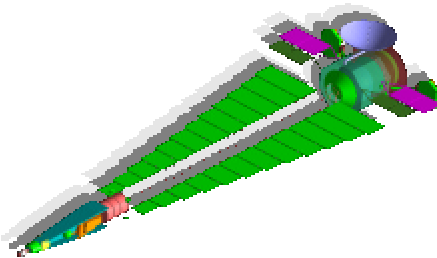
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# ESMD Program Overview

## Capability Development Programs



**Constellation Systems** will develop an **evolving System-of-Systems** that supports exploration at the Moon, Mars, and beyond, in support of the Vision for Space Exploration. Near-term activities include development of a **Crew Exploration Vehicle** for LEO operations and lunar transport.



The **Prometheus-1 Project** will demonstrate **nuclear fission-powered systems** in deep space, through a tour of Jupiter's icy moons to search for possible sub-surface oceans.



The **Hubble Robotic Servicing Mission** is a program focused on **safely de-orbiting and extending the service life** of the Hubble Space Telescope. Key technologies include autonomous rendezvous & docking, and on-orbit servicing robotics.





# **ESMD Program Overview**

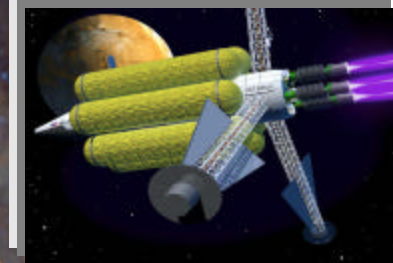
## **Research & Technology Programs**



**Exploration Systems Research & Technology** is a strategic, requirements-driven program focused on making systems more affordable, reliable, effective and flexible. Technology is developed **through a lifecycle**, from low-TRL **advanced research through technology maturation and demonstration**.



**Centennial Challenges** is a program of contests that **establishes cash awards to stimulate innovation and competition in technical areas of interest to Civil Space and Aeronautics**.



**Prometheus Nuclear Systems & Technology** is a strategic systems & technology development program that will enable **revolutionized** space exploration and science through **nuclear electric power and propulsion capabilities**.



**Human Systems Research & Technology** is a requirements-driven program focused on reducing long-duration mission cost and risk in the areas of **crew health & performance and life support & habitation including EVA**.



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# Implementing the Vision...

## Concept Exploration & Technology Progress

- **Lessons-learned reviewed and incorporated into management process**
  - Agency-wide, Orbital Space Plane, Next Generation Launch Technology
  - Lessons-learned incorporated into Risk Management Plan
- **Released Request for Information (May 04)**
  - Over 1000 responses
  - Incorporated into Concept Exploration & Refinement (CE&R) Broad Agency Announcement (BAA)
- **Released CE&R BAA (Jun 04)**
  - 37 proposals received; down-select to 11; on-board 8 Sep for 6 months to validate acquisition and requirements strategies
- **Released Intramural Call for Proposals (ICP) on System-of-Systems Technologies for Spiral 2 & beyond (May 04)**
  - 1300 Notices of Intents (NOIs) received; initial down-select to 137 full proposals; 47 projects selected (Jul 04)
- **Released Extramural BAA on System-of-Systems Technologies for Spiral 2 & beyond (Jul 04)**
  - 3700 NOIs received; initial down-select to 500 full proposals; ~ 100 projects to be selected (Nov 04)





# **Implementing the Vision...**

## **System Development Accomplishments**

- **Constellation System-of-Systems, CEV Preliminary Level 1 requirements and Concepts of Operations developed utilizing rigorous process:**
  - Strategy-to-Task-to-Technology (STT) process adopted as basis for prioritized investment strategy
  - Operational Advisory Group (OAG) established, populated, and led by operational users (astronauts, flight directors, logisticians, etc.) to validate requirements and priorities
  - Spirals 1, 2, 3 Requirements Identified (Decreasing definition from Spiral 1 to Spiral 3)
- **CEV RFP process initiated with target award date of Aug 05**
  - CE&R Contractor Teams influencing tech requirements & acquisition strategy, including potential commercial roles
- **Prometheus-1 (JIMO) spacecraft contract awarded September 20**
- **HSRT successfully demonstrated critical technologies**
  - Advanced Ultrasound diagnostic tool demonstrated “Telemedicine” from ISS
  - E-nose technology for air quality event monitoring successfully validated on ISS
- **Hubble Robotic Servicing Mission contract awarded October 1**



# Exciting Missions Ahead

## International Space Station

- ***Critical Human Factors Studies Onboard***

### Harmful Radiation Effects

- *Tissue degeneration*
- *Carcinogen exposure*

### Physiological Changes

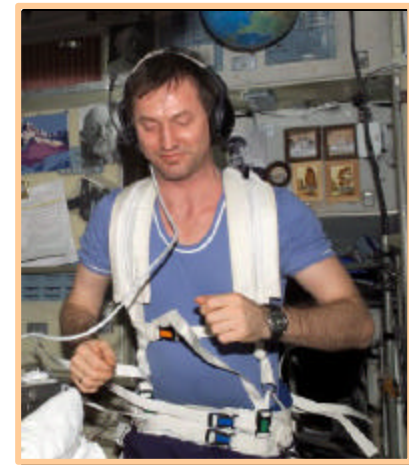
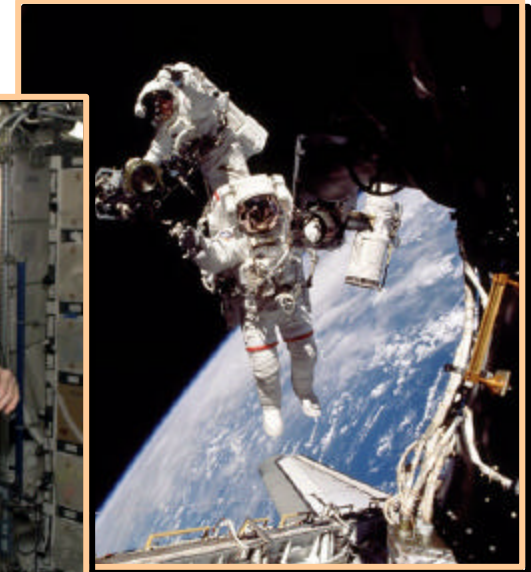
- *Cardiac arrhythmia*
- *Osteoporosis*

### Acute Medical Problems

- *Toxicity*
- *Ambulatory health problems*

### Behavioral Problems

- *Disorientation*
- *Sleep problems*



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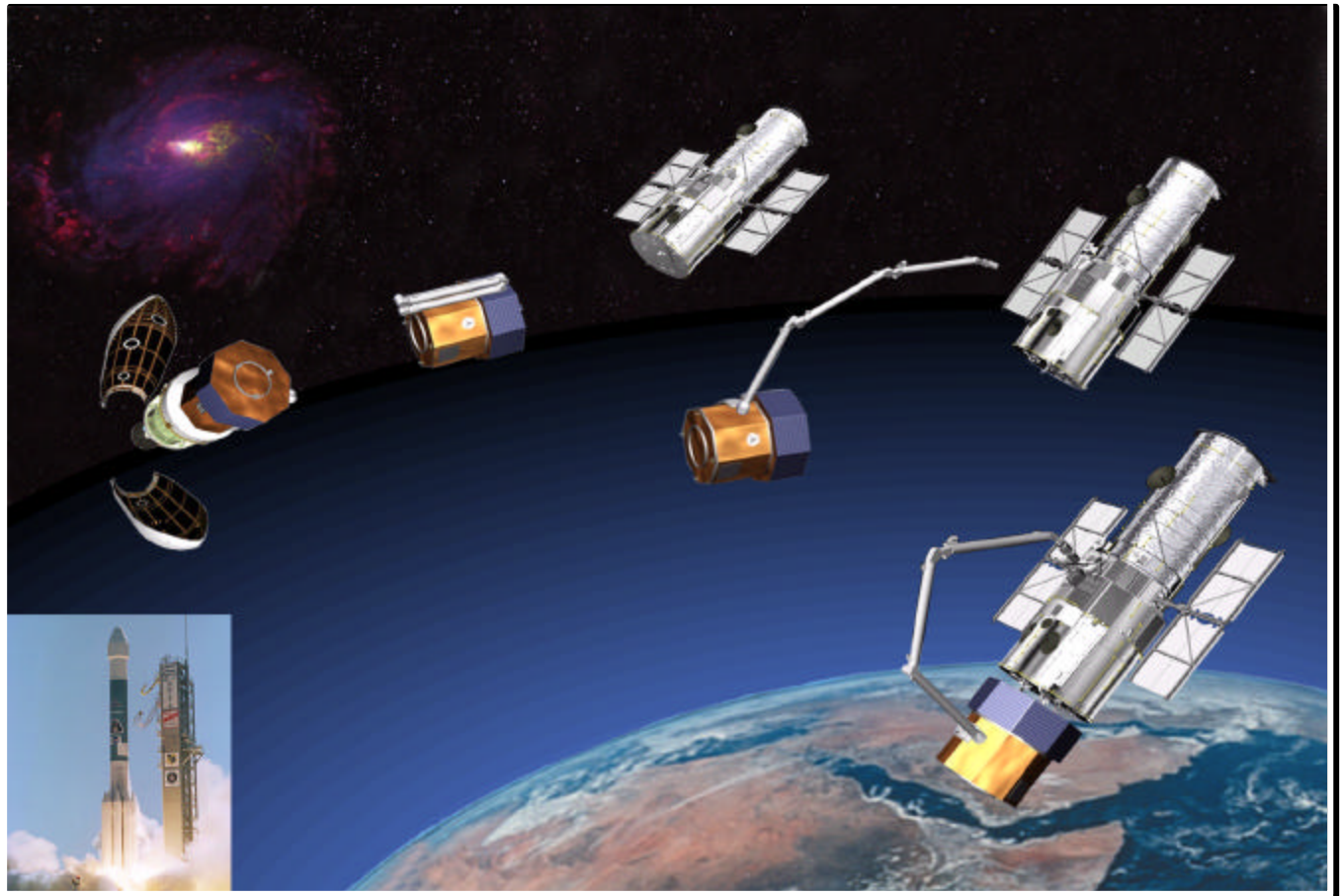




# Exciting Missions Ahead

## Hubble Robotic Servicing Mission

- *Mission Profile Supports Safe De-orbit, Life Extension*



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# Exciting Missions Ahead

## Prometheus-1

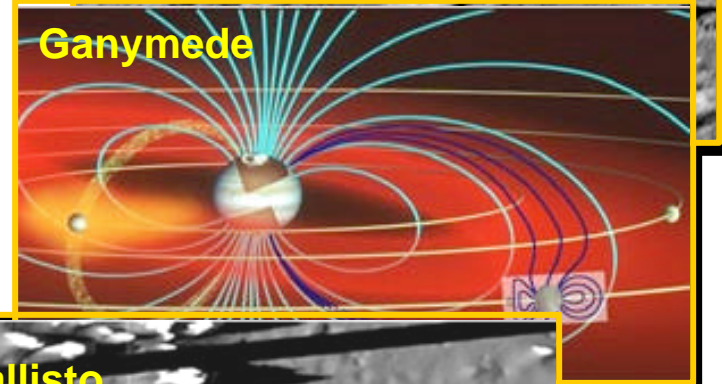
- Multi-mission power and propulsion technologies enable search for sub-surface oceans on Jupiter's moons*



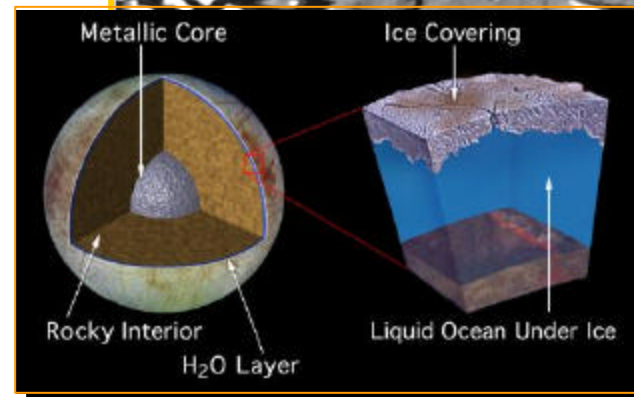
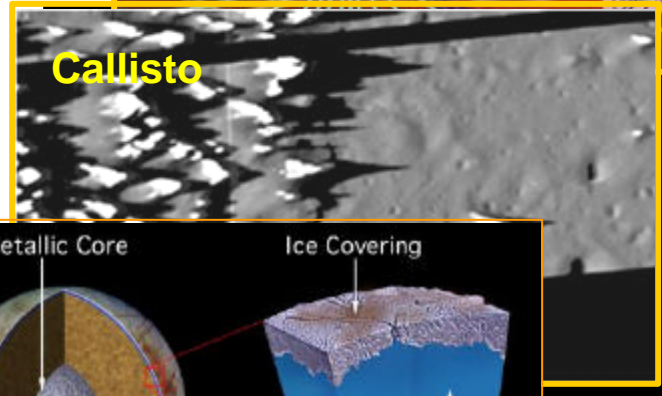
Europa



Ganymede



Callisto



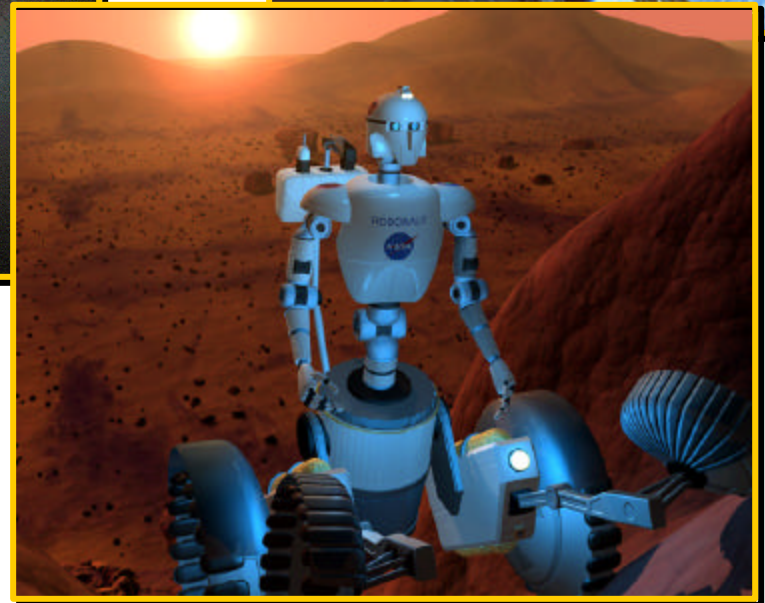


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# Exciting Missions Ahead

## New Era of Human-Robotic Operations

- New operations concepts leverage the capabilities of humans and robots where they are best-suited*





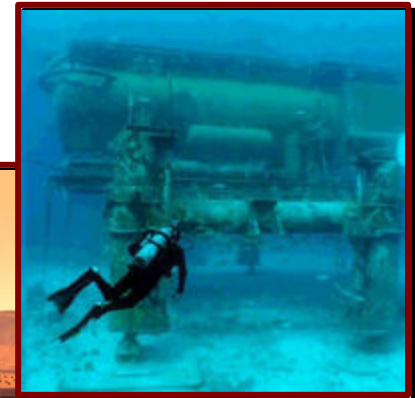
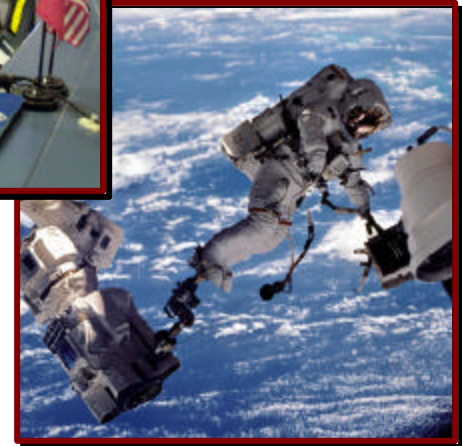


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# Contributing to the Vision

## Cross-Agency Integration

- Transit & Launch Systems for Crew Transport & Support
- Human Spaceflight
- Surface & Orbital Systems
- Supporting Basic & Applied Research
- Technology Development for Long Duration Habitation
- Operations Demonstrations





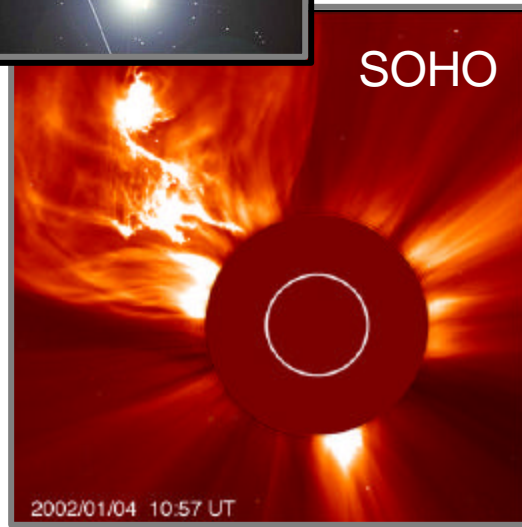
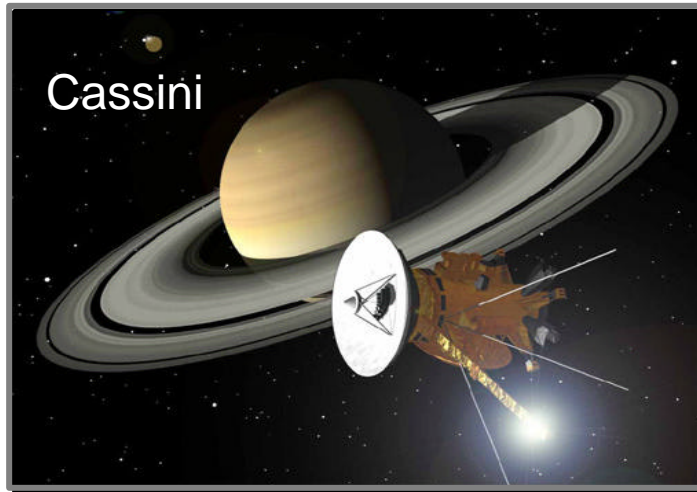


# Contributing to the Vision

## International Cooperation

- We will engage other nations to further our exploration goals***

International Space Station



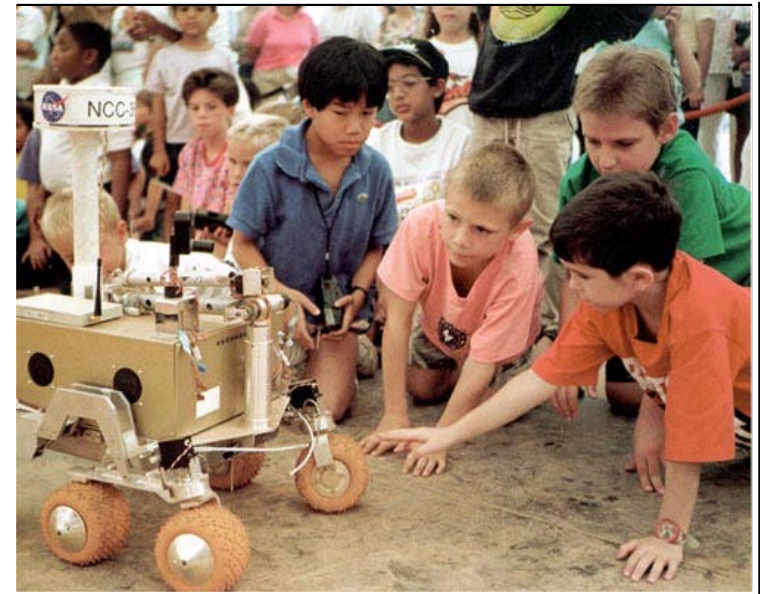
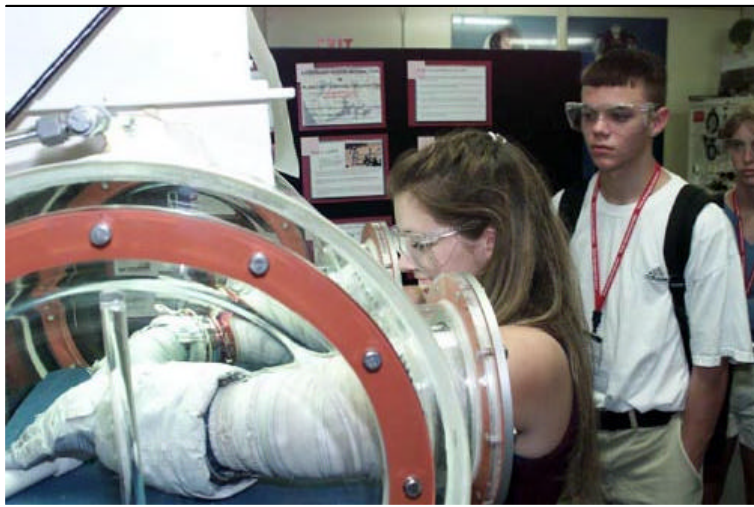
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# Contributing to the Vision

## Industry & Academic Partnership

- *Leverage our Nation's young and growing talent in science and engineering*
- *Develop clear and consistent messages, showing a united front among partners*
- *Engage broader communities*
- *Deliver on commitments, being responsible stewards of taxpayer dollars*
- *Educate, inspire, and motivate the public*



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# Realizing the Future

## **Foster and sustain the exploration culture across generations**

- *New frontiers yield scientific and commercial opportunities*
- *Pathfind new approaches to research, development, risk management*
- *A constant impetus to educate, train, and develop industrial base*

## **Identify, develop, and apply advanced technologies to...**

- *Enable exploration and discovery*
- *Allow the public to actively participate in the journey*
- *Translate the benefits of these technologies to improve life on Earth*

## **Harness the brain power**

- *Engage the nation's science and engineering assets*
- *Motivate successive generations of students to pursue science, math, engineering and technology*
- *Create the tools to facilitate broad national technical participation*





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# One Step at a Time

**Affordable, Sustainable, Focused, Achievable**

- *NASA has the talent, experience and leadership to fulfill our destiny as explorers*



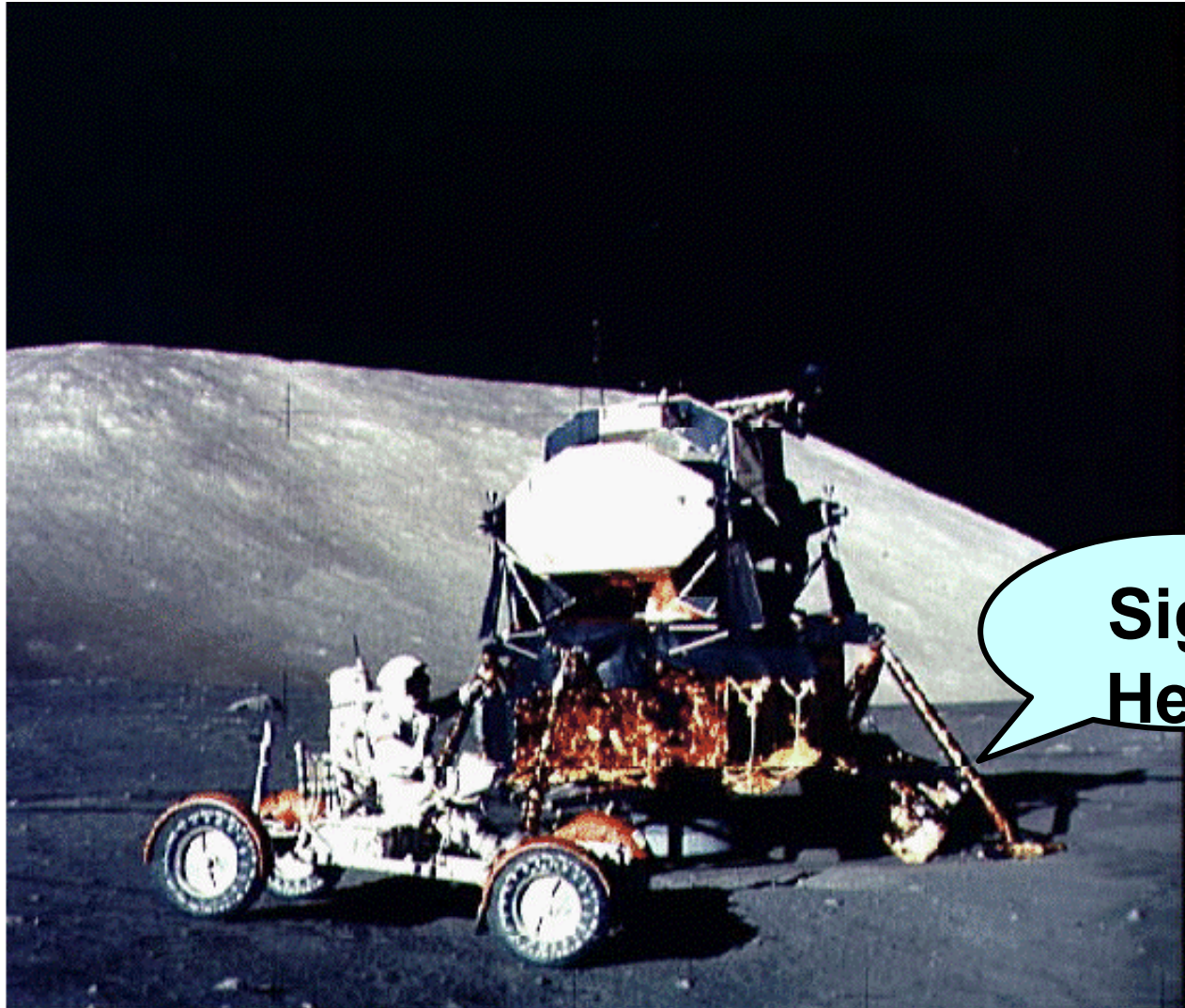




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# **“ We Leave As We Came...”**

## **Your Role in the Next Era of Exploration**



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***[www.nasa.gov](http://www.nasa.gov)***